Accuracy of the DTC torque control motor for nickel-titanium rotary instruments

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Abstract

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Aim To determine the torque output and examine the accuracy of five identical DTC torque control (DTC) motors.

Methodology Torque settings on the DTC motors for the .04 ISO ProFile nickel-titanium (NiTi) rotary instruments were evaluated at 350 r.p.m. A modification of the ANSI/ADA Specification No. 28 setup for the evaluation of torsional properties of endodontic instruments was used. A handpiece was attached to the motor and gripped with a vice. An .07 Orifice Shaper, size 50, was inserted in the handpiece. The instrument tip was clamped in a chuck connected to a torque sensor. The motor was then activated to rotate the instrument in a clockwise direction until reversal of the rotation occurred. The actual torque generated at the reversal of the rotation was recorded. Ten tests were carried out at each torque setting. A new Orifice Shaper was used for each test. The means of the actual torque values generated by the motors at the different torque settings were compared with the torque values claimed by the manufacturer and analysed using analysis of variance and the Student's *t*-test ($\alpha = 0.05$).

Results The actual torque values were significantly higher than the torque preset on the motors ($P < 0.0001$) and did not differ significantly among the motors ($P > 0.05$).

Conclusions The actual torque deviated from the preset torque and was higher than the reported torque at fracture of several NiTi rotary instruments. The usefulness of these motors is questionable.

Keywords: accuracy, fracture, nickel-titanium, ProFile, rotary, torque control motor.

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Introduction

The separation of nickel-titanium (NiTi) rotary instruments is a serious concern in endodontic therapy. Several studies have evaluated the influence of various factors on the separation of endodontic NiTi rotary instruments (Barbakow & Lutz 1997, Pruett *et al.* 1997, Ramirez-Salomon *et al.* 1997, Bryant *et al.* 1998, Gabel *et al.* 1999, Mandel *et al.* 1999, Yared *et al.* 2001). During root canal preparation the instruments are subjected to different levels of torsional stress (torque) (Blum *et al.* 1999a,b, Sattapan *et al.* 2000, Peters *et al.* 2003). If the level of torque is equal or greater than the torque at fracture, the instrument will separate.

Different types of motors are used in conjunction with the NiTi rotary instruments: the air and electric motors without torque control, and the electric torque control motors. Theoretically the torque control motors take into consideration the torque at fracture of the NiTi rotary instruments. Torque values lower than the torque at fracture of the rotary instruments can be set on the torque control motors. Presumably the motor will stop rotating and even reverse the direction of rotation when the instrument is subjected to torsional stress equal to the torque level set on the motor. Consequently, instrument fracture would be avoided.

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A variety of motors with controlled torque levels have been developed. The DTC torque control motor (DTC) (Tulsa Dentsply, Johnson City, TN, USA) is widely used with NiTi rotary instruments. On this motor, different torque levels for the GT, ProFile and ProTaper (Tulsa Dentsply, Tulsa, OK, USA) NiTi rotary instruments are preset by the manufacturer. Three torque settings are available for the ProFile ISO instruments with 0.04 mm mm^{-1} taper (Tulsa Dentsply): according to the manufacturer, settings 1, 2 and 3 correspond to 1.3, 1.1 and 0.75 N cm for the ProFile instruments sizes 40 and 35, sizes 30 and 25, and sizes 20 and 15, respectively, when used with a handpiece with a 16 : 1 reduction ratio (Dentsply/Tulsa Dental 2003).

The accuracy of torque control motors used in endodontics with NiTi rotary instruments has not been evaluated. In addition, some studies have shown that torque-limiting devices used in implantology exhibited substantial variations from set torque values (Standlee & Caputo 1999, Standlee *et al.* 2002).

The purpose of this investigation was to determine the actual torque corresponding to the ProFile torque settings, and to evaluate the accuracy of the torque settings on different DTC motors.

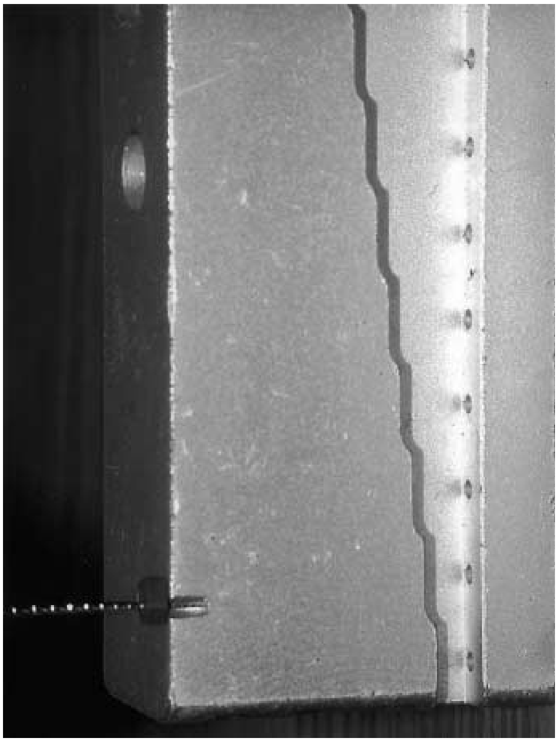

Figure 1 Jig used to ensure reproducible positioning of the tip of the instrument in the chuck.

Materials and methods

A modification of the ANSI/ADA (1988) Specification No. 28 setup for the evaluation of torsional properties of endodontic instruments was used.

Five new DTC (AEU-25T Electronic Endodontic System; Tulsa Dentsply) motors were obtained from the manufacturer. A handpiece with a 16 : 1 reduction ratio was attached to the motor. The handpiece was gripped with a vice. A size 50 Orifice Shaper (Tulsa Dentsply), with a 0.07 mm mm^{-1} taper was inserted in the handpiece. Five millimetres of the tip of the instrument were clamped tightly in a chuck with brass jaws connected to the digital torque meter memocouple (A-Tech Instruments Limited, Scarborough, Ontario, Canada) and to a computer for measurement recording using the LabView software (National Instruments, Austin, TX, USA). A jig was constructed to ensure reproducible positioning of the tip of the instrument in the chuck (Fig. 1). Torque settings 1, 2 and 3 were evaluated at 350 r.p.m. Ten tests were carried out at each torque setting. A new Orifice Shaper was used for each test. The digital torque meter memocouple was calibrated before each test. The torque value at which the motor reversed the rotation of the instrument was recorded. The mean of the torque values generated by each motor at the different torque levels were determined and analysed using analysis of variance and the Student's *t*-test; significance was set at the 95% level.

Results

The mean of the actual torque values generated by each of the five motors at the different torque levels are shown in Table 1. For the purposes of the present study, the preset torque was assumed to be constant at the values provided by the manufacturer, and therefore the standard deviation was assumed to be equal to zero. For each torque setting, and for the five motors, the actual torque value was significantly higher than the torque preset on the motor and claimed by the manufacturer ($P < 0.0001$). In addition, for the different torque settings, the actual torque values did not differ significantly found among the five motors ($P > 0.05$).

Discussion

During canal preparation instruments might lock into the canal. Locked instruments are subjected to high

Table 1 Mean of the actual torque in N cm and standard deviation ($n = 10$) at the different torque settings for each of the five motors

Torque settings	Setting 1 (1.3 N cm)[a]	Setting 2 (1.1 N cm)	Setting 3 (0.75 N cm)
Motor 1	1.85883 (0.0500)	1.42789 (0.0909)	0.78391 (0.0473)
Motor 2	1.85049 (0.0740)	1.42599 (0.0779)	0.78474 (0.0662)
Motor 3	1.84676 (0.0655)	1.42340 (0.0594)	0.78577 (0.0989)
Motor 4	1.85817 (0.0656)	1.41998 (0.0791)	0.78346 (0.0677)
Motor 5	1.85593 (0.0607)	1.42119 (0.0668)	0.78346 (0.0507)

[a]Torque value in N cm corresponding to the torque setting as claimed by the manufacturer.

levels of torsional stress, frequently leading to fracture. Torque control motors are supposed to reduce the incidence of instrument fracture during canal preparation; when the instrument is subjected to torque levels equal to the torque set on the torque control motor, the motor reverses the rotation of the instrument and fracture should be avoided. However, recent studies did not show significant differences among the different types of motors in terms of instrument fracture (Bortnick *et al.* 2001, Yared & Sleiman 2002, Yared *et al.* 2003). This study appears to be the first to evaluate torque settings on torque control motors.

A large instrument, the Orifice Shaper (Tulsa Dentsply) size 50 with a 0.07 mm mm^{-1} taper, was used in the present study to avoid instrument fracture during the testing procedure, especially at the higher torque levels. In a preliminary study, this instrument did not fracture when gripped 5 mm from its tip during the testing procedure; smaller instruments including the ProFile size 40 fractured at the higher preset level of torque used in the present study (setting 1 corresponding to 1.3 N cm according to the manufacturer) before the motor reversed the rotation.

As a general rule, in a torsional loading model, the torque is independent of the twisting rate (rotational speed) (Bailey 1985). Consequently, the instrument was rotated clockwise at 350 r.p.m. as recommended by several manufacturers for NiTi rotary instruments. The motor reversed the rotation of the instrument when the latter was subjected to stress equivalent to the torque value preset on the motor.

Interestingly, for the different torque settings, the actual torque values (torque at which the reversal of the rotation occurred) were significantly higher than the torque set on the motor and claimed by the manufacturer. These results were in agreement with other studies that showed similar significant variations in devices used in implantology (Standlee & Caputo 1999, Standlee *et al.* 2002). Moreover, it was noted that the actual torque values corresponding to the reversal of the rotation were greater than the torque at fracture of several NiTi rotary instruments as reported in the literature. Wolcott & Himel (1997) showed the torque at fracture for 0.04 taper ProFile NiTi rotary instruments (Tulsa Dentsply) sizes 15, 25 and 35 were 0.21, 0.48 and 1.24 N cm, respectively. Consequently, if these instruments lock into a canal, fracture will likely occur because the torque at fracture will be reached prior to the torque set on the motor at which rotation is reversed (actual torque value). Fracture of the ProFile instrument size 25 would even occur at setting 3 available on the DTC for the ProFile instruments and corresponding to an actual torque value of approximately 0.78 N cm. However, the size 35 ProFile would not fracture if used at setting 1 because its torque at fracture (1.24 N cm) is higher than the actual torque value of setting 3 ($\sim$0.78 N cm) at which rotation reversal would occur.

The results of the present study did not demonstrate, for the different torque settings, significant variations among the five tested motors. However, the motors used in the present study were new and obtained directly from the manufacturer.

Conclusions

The actual torque output of the DTC motor deviated from the preset torque value claimed by the manufacturer and was higher than the torque at fracture of some ProFile NiTi rotary instruments. The usefulness of this torque control motor in reducing instrument fracture is questionable.

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